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Assessing 'Meidum Geese' species identification with the 'Tobias criteria'

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ABSTRACT

Animals depicted by ancient artisans have the potential to provide insights into taxa encountered by past cultures. While qualitative approaches are commonly used to identify animals to species level, the use of more objective approaches has the potential to reduce bias and uncertainty. Here, I used the 'Tobias criteria', a quantitative method for delimitating avian species in a novel way to examine the 'Meidum Geese' from the Chapel of Itet with their purported candidate taxa. I compared the visual appearance of the colouration and body markings in this painting with greylag geese (*Anser anser*), bean geese (*A. fabalis*), greater white-fronted geese (*A. albifrons*), and red-breasted geese (*Branta ruficollis*). I found of the three different graphically represented geese types, one form resembles greylag geese (but did not exclude bean geese), a second form is like greater white-fronted geese, but the third goose type did not plausibly match with red-breasted geese. Considering that other faunal representations from the Chapel of Itet show accurate modern species-level portrayals, it is unclear if the third 'Meidum Geese' type depicts a novel phenotype of an extinct taxon, a misrepresentation of an extant but locally extinct taxon, or is a fabrication that has incorporated several goose features.

1. Introduction

Ancient graphical representations of animals can provide insights into the fauna that ancient humans encountered, which can be of particular importance when excavated faunal remains are absent (Guagnin et al., 2018). The provenance of these artistic records has revealed historical biogeographical ranges of extant taxa and sequences of faunal range contraction (Steelman et al., 2002; Guthrie, 2005; Kimura et al., 2010; Gunn et al., 2011; Lewis, 2017; Bernáldez-Sánchez and García-Viñas, 2019; Morcote-Ríos et al., 2020). Ancient Egyptian depictions of non-human taxa have also attracted interest in such studies, in part because their detail permits species-level identifications (Houlihan, 1986; Osborn and Osbornová, 1998), the cultural significance and comparative abundance of certain species (Ikram, 2012), the relative ease to date such works (Yeakel et al., 2014), and the region being part of a greater geographical area that has impoverished biodiversity when compared with that of the African humid period (Watrin et al., 2009; Migliore et al., 2013; Faith, 2014). While some species have become absent from Egypt in recent times (Wasef et al., 2019), some contracted their biogeographical ranges during Pharaonic times (Houlihan, 1986; Osborn and Osbornová, 1998; Manlius, 2000; Nicolas, 2001, 2009), and others have become globally extinct (Beierkuhnlein, 2015). As noted, however, graphical representations of ancient Egypt were constrained by cultural rules (Schäfer et al., 1974; Robins, 1997) and when not taken into consideration, have the potential of reducing their use in zoological and ecological inferences (Evans, 2015).

Excavated remains of animals from archaeological sites confidently show the contemporaneous co-occurrence of taxa and ancient cultures and provide support as having been the subjects of particular graphically represented forms (Houlihan, 1986; Wyatt, 2012). Despite this, comparatively few species identifications are "beyond all reasonable doubt" (Wyatt, 2012:90). While some more objective approaches statistically compare the morphology of depicted forms with their purported candidate taxa (Cobden et al., 2017; Bernáldez-Sánchez and García-Viñas, 2019) they rely heavily on how accurately the ancient artisans represented the species' anatomical proportions in those depictions.

The 'Tobias criteria' is an approach that provides an objective framework to assess the status of any avian taxon (Tobias et al., 2010) and has been effective in delimiting modern species (del Hoyo and Collar, 2014). This method scores the characters (and contexts) between closely related taxa on a scale of dissimilarity, such that a combination of low scores shows taxa as very similar and a greater the chance of being attributed to a single taxon (e.g., subspecies variants), in contrast with high-scoring compared taxa denoting high proportions of dissimilarities and a higher chance of not being attributed to the same species.

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However, the 'Tobias criteria' has never been applied to species identified from ancient artwork. In this paper, I present the 'Tobias criteria' as a novel approach to re-examine how well the birds represented in an ancient Egyptian artwork match with their purported candidate species. Here, the 'Meidum Geese' depiction originally from the Chapel of Itet, Meidum (Museum of Egyptian Antiquities, Cairo, JE34571/ CG1742) is compared with the visual appearance of the avian taxa greylag geese (Anser anser), bean geese (A. fabalis), greater white-fronted geese (A. albifrons), and red-breasted geese (Branta ruficollis) (Goelet, 1983; Houlihan:57, 1986; Arnott, 2009; Wyatt, 2013; Callahan, 2014). In this context, this study aims to assess the extent to which these modern taxa resemble those in the 'Meidum Geese' depiction, albeit the degree by which the 'Tobias criteria' delimit such species and ancient graphic representations. Throughout this paper, I refer the depicted three goose forms as 'Meidum Geese 1′, 'Meidum Geese 2′, and 'Meidum Geese 3′ to denote that their identifications are being tested rather than assumed to be correctly illustrating the purported candidate species.

The 'Meidum Geese' from the Chapel of Itet

Excavations of mastaba 16 from the early Fourth Dynasty (c. 2600 BCE), Meidum (Fig. 1) occurred in the late 19th century (Mariette, 1882; Petrie, 1892) and exposed the burial chambers of Nefermaat and his wife Itet. These chambers bore chapel walls richly adorned with frescos, including the graphic representation of many types of animals: dogs, cattle, leopard, and addax (Petrie, 1892: Pls XVII–XXVIII; Smith, 1937, Pl. IV). Most famous among these are the 'Meidum Geese', originally depicted on the outer corridor of the chapel of Itet (Fig. 1C). In the original configuration, the panel of six painted geese separated a scene of a bird-hunt from the above register and a scene with fields being ploughed from the below register (Smith, 1937; Goelet, 1983). While Itet's frescos were plundered within decades of discovery, the acquisition of the 'Meidum Geese' by Vassalli ensured the conservation of the 'Meidum Geese' within the Museum of Egyptian Antiquities, Cairo (Fig. 2) (Smith, 1937; Goelet, 1983).

The 'Meidum Geese' has been acclaimed "one of the great masterpieces of the Egyptian animal genre" (Houlihan, 1986:57) and "one of the finest pieces of painting ever created by an Egyptian artist" (Smith, 1937:23). Three left-facing birds stand with one pair to the rear of a larger solitary grazer and is mirrored to the right (Fig. 2) in "naturalistic attention to detail… unsurpassed in Egyptian art" (Goelet, 1983:41). Included in the work are "extraordinary" details such as bill serrations, feather veins, and leg scales (Goelet, 1983:43). From an ornithologist point of view, the Old Kingdom 'Meidum Geese' is credited as the "first recorded birds that could clearly be identified to species level" (Callahan, 2014:14).

While there is a consensus that the 'Meidum Geese' is painted with acute attention to detail and that the greater white-fronted geese (A. albifrons) is one represented species (Nicoll, 1919; Smith, 1937; Raven, 1947; Goelet, 1983; Strudwick et al., 1990; Arnott, 2009; Wyatt, 2012, 2013), the attribution of the other 'Meidum Geese' is not universally agreed upon. For one, there is disagreement whether another depiction represents greylag geese (A. anser) or bean geese (A. fabalis) (Goelet, 1983; Wyatt, 2013; Callahan, 2014). However, more polarising is the degree to which the extant taxon red-breasted geese (*B. ruficollis*) is represented, with some considering the identification "certain" (Nicoll, 1919:70), "straightforward" (Wyatt, 2013:2) and bearing an "unmistakable" likeness (Raven, 1947:i), while others notes the depiction "differs significantly from that of the [red-breasted geese] birds known today" (Weesie, 1988:13) with "serious discrepancies" (Goelet, 1983:45) that may instead illustrate a distinct population of *Branta* geese that is now extinct (Voous in Weesie, 1988:13).

Considering that the phenotypic characters of the 'Meidum Geese' have never been comprehensively evaluated, the question remains: how accurately does the painting reflect their purported candidate taxa? To address this, I use the 'Tobias criteria' and assess the extent to which the 'Meidum Geese' plausibly resembles greylag geese (*A. anser*) or bean geese (*A. fabalis*), greater white-fronted geese (*A. albifrons*), and red-breasted geese (*B. ruficollis*).

2. Methods

The 'Tobias criteria' is a framework of quantitatively assessing species-level boundaries between closely related avian taxa. The taxonomic decisions are highly objective and provides consistency and transparency (Tobias et al., 2010). It has been used extensively across disciplines of taxonomy and conservation biology (e.g. Braby et al., 2012; del Hoyo and Collar, 2014; Zachos, 2016; Frankham et al., 2017). The 'Tobias criteria' assesses a broad range of characters (and contexts) such as ecology and behaviour, acoustics, geographical relationship, morphology (i.e., size), and visual appearance (i.e., plumage colouration). Here, two related avian taxa that are similar are scored low, while greater dissimilarities score comparatively high. When combined scores exceed the boundary limit, the 'Tobias criteria' does not consider the taxa to be of the same species. Character scores of zero denote identical traits, while scores increasing from one to four are for increasing degrees of differences (i.e., minor, moderate, major, and exceptional). The total combined scores equivalent to or exceeding seven points designate the compared forms as distinct species (Tobias et al., 2010).

Vocalisations, geographical relationships, ecology and breeding behaviour are not represented with the 'Meidum Geese' and excluded from the analysis. Comparative body size has significant symbolism within ancient Egyptian art (Schäfer et al., 1974; Robins, 1997; Tiradritti, 2015) and so morphological data, such as body size (a proxy for body weight) were excluded from the study. In this context, the 'Tobias criteria' category of 'visual appearance' was utilised in comparing the 'Meidum Geese' and their purported candidate taxa (i.e., 'Meidum Geese 1′ with both greylag geese (*A. anser*) and bean geese (*A. fabalis*); 'Meidum Geese 2′ with greater white-fronted geese (*A. albifrons*); and 'Meidum Geese 3′ with red-breasted geese (*B. ruficollis*). In those instances where a single trait varied in its difference (e.g., colour patterning of different breast regions scores of 2–3), only the lowest value was applied. In tallying the scores of 'visual appearance' only the three

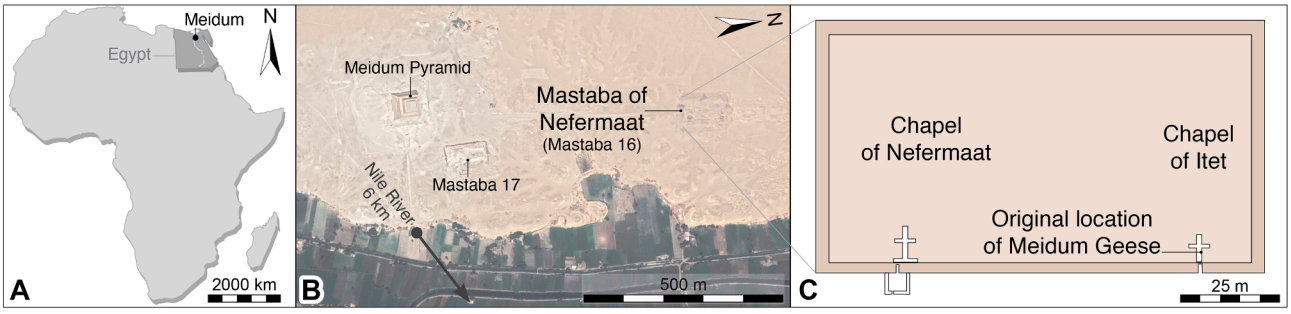

Fig. 1. A, Locality of Meidum, Egypt, Africa; B, Satellite image of the Ancient Egyptian structures of Meidum, © Google 2019; C, Schematic of Mastaba of Nefermaat that contains the Chapel of Itet where the Meidum Geese were located (adapted from Petrie, 1892:Pl. V). Colour online.

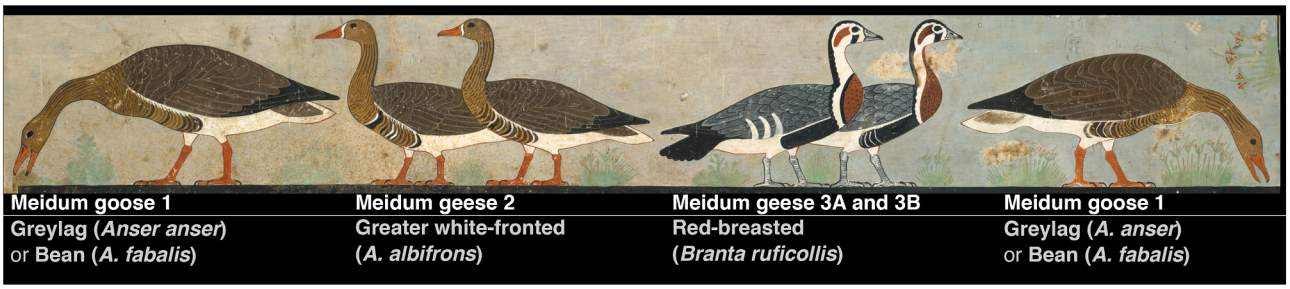

Fig. 2. The Meidum Geese originally from the outer wall of the Chapel of Itet, mastaba of Nefermaat and Itet, Dynasty 4, Meidum, now housed in the Museum of Egyptian Antiquities, Cairo (JE34571/ CG1742), Egypt (Wilkinson, 1920–1921). Top line of text are references to the geese types, followed by purported candidate taxa. Colour online.

highest scores for each goose type were combined (Tobias et al., 2010). Where the combined scores were less than seven, the depiction of the respective 'Meidum Geese' was considered being within the limit of the candidate species, in contrast with a score of seven or above interpreted as outside of the species limit and thus considered an unlikely (or very poorly represented) candidate.

Visual representations of the 'Meidum Geese' and their purported candidate taxa were based on analysing high-resolution images accessed from print and online sources (Wilkinson, 1920–, 1921; de Juana, 1992; Pingstone, 2004; Blossom, 2011; del Hoyo and Collar, 2014) and supplemented by first-hand observations of individuals (pers. obs. Kölner Zoo, 2018). The descriptions of the external appearance (Tables 1 and 2) followed standard avian anatomical terms (de Juana, 1992).

3. Results

Thirteen 'visual appearance' traits of the 'Meidum Geese' were scored for their magnitude of differences with their purported candidate taxa. These traits were the bill, eye, face, neck, breasts, belly, flank, vent, upper tail-coverts, tail, wings, tibia, and legs (Tables 1 and 2). Each 'Meidum Goose' had 'identical' traits with those of their purported candidate species, and traits of 'minor' and 'moderate' differences. None had 'exceptionally' dissimilar features (Tables 1 and 2; Figs. 2 and 3). Only 'Meidum Geese 3′ had 'majorly' different traits from its proposed candidate species the red-breasted geese (*B. ruficollis*; Table 2; Figs. 2 and 3).

Table 1
Comparative analysis and magnitude of difference scores of Atet's geese 1 (Meidum Geese, Chapel of Atet, Old Kingdom, Egypt) and purported modern candidate taxa Greylag geese (*Anser anser*) and Bean geese (*A. fabalis*), and Atet's geese 2 with purported modern candidate taxon Greater white-fronted geese (*A. albifrons*). Scores indicate values of difference, where '0′ equals identical traits, '1′ minor differences, and '2′ equals moderate differences. No scores of '3′ or '4′ (minor and exceptional differences, respectively) were made in this sample set. Values in brackets indicate sub-scores. 'ND' denotes traits of no difference. Only the minimum sub-trait value provided the score for the trait.

Trait	Atet's Geese 1	*Anser anser* difference	Score	*Anser fabalis* difference	Score	Atet's geese 2	*Anser albifrons* difference	*Score*
Bill			0		0			1
	Streamlined with head	ND	[0]	ND	[0]	Streamlined with head	Bill is not streamlined with head	[2]
	Orange with black tip	ND	[0]	Bill black and orange with black tip	[2]	Orange with black tip	Bill is pink	[2]
	Dorsoproximal margin at eye level	ND	[0]	ND	[0]	Dorsoproximal margin at eye level	Dorsoproximal bill margin below eye level	[2]
	Long length		[0]	Moderate length	[1]	Long length	Moderate length	[1]
Eye	dark eye, orange ring		0	No orange eye-ring	1	Dark eye, dark ring		0
Face	Uniformly brown, as neck and breast	Grey-brown coloured	1	Darker face	2	Brown face with white border at bill base	Dark brown edge at the white border of face	1
Neck			0		0			0
	Concertina neck-feather folds	ND	[0]	ND	[0]	Concertina neck-feather folds	ND	[0]
	Uniformly brown, as face and breast	Grey-brown coloured	[1]	Grey-brown coloured	[1]	Brown, as face and breast	Grey-brown coloured	[1]
Breast			0		0			0
	Some barring	ND	[0]	ND	[0]	Some barring	ND	[0]
	Uniformly brown, as face and breast	Grey-brown coloured	[1]	Grey-brown coloured	[1]	Uniformly brown, as face and breast	Grey-brown coloured	[1]
Belly	Much barring with white dorsal border	ND	0	ND	0	Much barring with white dorsal border	ND	0
Flank	White flank	ND	0	ND	0	White flank	ND	0
Vent	White vent	ND	0	ND	0	White vent	ND	0
Upper tail-coverts	White or brown upper tail-coverts	White upper tail-coverts	0	White upper tail-coverts	0	Brown upper tail-coverts	White tail-coverts	2
Tail	Brown with white border	ND	0	ND	0	Brown with white border	ND	0
Wings	Brown feathers (lighter margins), darker primaries	ND	0	ND	0	Brown feathers (lighter margins), darker primaries	ND	0
Tibia	White tibia	Grey-brown coloured tibia	2	Grey-brown coloured tibia	2	White tibia	Grey-brown coloured tibia	2
Legs	Orange legs	ND	0	ND	0	Orange legs	ND	0

Table 2
Comparative analysis and magnitude of difference scores of Atet's geese 3 (Meidum Geese, Chapel of Atet, Old Kingdom, Egypt) and purported modern candidate taxa Red-breasted geese (*Branta ruficollis*). Scores indicate values of difference, where '0′ equals identical traits, '1′ minor differences, '2′ equals moderate differences, and '3′ equals major differences. No scores of '4′ (exceptional differences) were made in this sample set. Values in brackets indicate sub-scores. 'ND' denotes traits of no difference. Only the minimum sub-trait value provided the score for the trait.

Trait	Atet' goose 3A	Atet' goose 3B	*Branta ruficollis* difference	Score
Bill				1
	Streamlined with head	Streamlined with head	Bill is not streamlined with head	[2]
	Bill grey with black tip	Bill grey with black tip	Black	[2]
	Dorsoproximal margin at eye level	Dorsoproximal margin at eye level	Dorsoproximal margin below eye level	[2]
	Medium length	Medium length	short length	[1]
Eye	Dark eye	Dark eye	ND	0
Face				3
	Predominately white face	Predominately white face	White lores ventrally expanded	[3]
	Check-stripe dark-coloured discontinuous with eye	Check-stripe dark-coloured discontinuous with eye	Black vertical eye-stripe	[3]
	Eye-stripe red-coloured discontinuous with eye	Red-coloured (with dark streaks) eye-stipe discontinuous with eye	Rufous 'eye-stripe' subcircular and surrounded by broad white border	[3]
Neck				3
	Dorsally black with irregular border to white ventral neck	Dorsally black, middle white, and ventrally red (dark streaks)	Thick black dorsal neckline, rufous ventral neckline continuous with crown and breast (respectively)	[3]
	Broad white colouring is continuous with face and breast		Thin white and thinner black lateral lines	[3]
Breast				2
	Rufous with dark spots, surrounded by black margin	Dark red with darker spots and streaks	Rufous colour and patterning	[3]
	Broad white colouring is continuous with neck and face	Broad white colouring is continuous with neck and face	Rufous colour and patterning	[3]
	Black transverse-band	Black transverse-band	White transverse-band	[2]
Belly	Black	Black with white edges	Black with white edges	0–1
Flank	Three enlarged flank-plumes		No enlarged plumes	3
Vent	White		ND	0
Upper tail-coverts	Black		White	2
Tail	Black		ND	0
Wings	Slate-grey coloured, black primaries	Slate-grey coloured, black primaries	Black	2
Tibia	White	White	ND	0
Legs	Light-coloured	Light-coloured	Dark-coloured	2

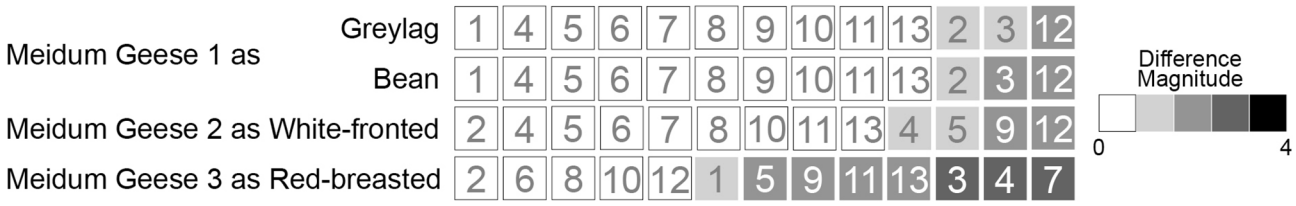
Meidum Geese 1 as
Greylag
Bean
Meidum Geese 2 as White-fronted
Meidum Geese 3 as Red-breasted
1 4 5 6 7 8 9 10 11 13 2 3 12
1 4 5 6 7 8 9 10 11 13 2 3 12
2 4 5 6 7 8 10 11 13 4 5 9 12
2 6 8 10 12 1 5 9 11 13 3 4 7
Difference Magnitude
0
4

Fig. 3. Colour-coded magnitude of difference in the visual appearance between the 'Meidum Geese' and proposed candidate taxa. Numerical values signify the trait that being assessed: 1, bill; 2, eye; 3, face; 4, neck; 5, breast; 6, belly; 7, flank; 8, vent; 9, upper tail-coverts; 10, tail; 11, wings; 12, tibia; 13, unfeathered legs. The colouring of squares signifies trait differences between depiction and species: white = identical; light grey = minor difference; mid-grey = moderate difference; dark grey = major difference; black = exceptional difference. The 'Tobias criteria' for 'visual appearance' combines only the three highest difference-scores for each taxon: 'Meidum Geese 1 with Greylag (4) and Bean (5); 'Meidum Geese 2′ with Greater White-fronted (5); and 'Meidum Geese 3′ with Red-breasted (9).

3.1 'Meidum Geese 1′

Greylag geese (*A. anser*) and bean geese (*A. fabalis*) share many similarities with 'Meidum Geese 1′ (Figs. 2–3; Table 1). Both taxa were identical in belly, flank, vent, tail, wing and leg traits, however, only the greylag geese shared additional features of the bill, eye, and (in one depicted bird) colouration of the upper tail-coverts. Some regions of the neck and breast of greylag and bean geese were also similar to 'Meidum Geese 1′ (i.e., concertina neck-feather folds, and barring markings, respectively). Minor to moderate differences were present in colouration to the face, neck, breast, tibia, and (in one depicted bird) the upper tail-coverts. Bean geese had additional differences in the colouration and patterning of the bill and darkening of the face region. Using the 'Tobias criteria', dissimilarity scores of the depiction and greylag geese is three, while the bean geese score five. This is below the threshold for delimiting species for both species, suggestive that either could be possible candidate taxa for 'Meidum Geese 1′ although the greylag goose seems a more likely based on the fewer number of differences than the bean goose.

3.2. 'Meidum Geese 2′

Greater white-fronted geese (*A. albifrons*) shared identical colouration with 'Meidum Geese 2′ in the eye, belly, flank, vent, tail, wing, and legs (Figs. 2–3; Table 1). I observed minor to moderate differences for the neck and breast colouring, shape, length, and colouring of the bill, some regions of the face, and colouring of the tibia and upper tail-coverts. The 'Tobias criteria' score the differences as five, a value below the threshold for delimiting these as separate species and thus does not exclude the greater white-fronted geese as a candidate for 'Meidum Geese 2′.

3.3. 'Meidum Geese 3′

Red-breasted geese (*B. ruficollis*) shared identical traits with those depicted in 'Meidum Geese 3′ (Figs. 2–3; Table 2) in the colouration of eyes, tibia, vent, under tail-coverts, and tail. The belly feathers are black either with white tips (in 'Meidum Geese 3B' and *B. ruficollis*) or not ('Meidum Geese 3A'). Minor differences occurred in the bill, while moderate differences are in the upper tail-coverts, wing, legs, and some areas of the breast. Significantly, regions of the face, neck, flanks, and much of the breasts show major differences in colour and patterning. Here, 'Meidum Geese 3′ have predominately white faces and necks, and the eye- and cheek-stripes differing in configuration from *B. ruficollis*. The depictions either lack red colouration on the neck ('Meidum Geese 3A') or are slight ('Meidum Geese 3B'), have less red on the breast then *B. ruficollis* but with mottled breast patterning absent in the extant species. The flank of 'Meidum Geese 3A' has three elongate, dorsocaudally directed feathers passing over, but not aligned with, the greater and lesser coverts of the wing. This feature has been previous considered to represent three wing-bars (Goelet, 1983; Houlihan, 1986). 'Meidum Geese 3′ appear strongly dimorphismic whereas *B.* ruficollis immatures are paler in colouring but do not differ in adult face, neck, or breast patterning (as present between 'Meidum Geese 3A and B'), and also there are no differences between the sexes. Combining scores of three major differences produces a value of nine, surpassing the threshold for species delimitation (seven points) as specified by the 'Tobias criteria'. Even if the one of the moderate differences (e.g., breasts) replaces the scoring of a major difference (e.g., three elongate flank feathers), the combined score (eight) exceeds the threshold value. This signifies that the depicted 'Meidum Geese 3′ contrasts with the visual appearance of the red-breasted geese (B. ruficollis).

Table 1. Comparative analysis and magnitude of difference scores of 'Meidum Geese 1′ ('Meidum Geese', Chapel of Itet, Old Kingdom, Egypt) and purported modern candidate taxa Greylag geese (*Anser anser*) and Bean geese (*A. fabalis*), and 'Meidum Geese 2′ with purported modern candidate taxon Greater white-fronted geese (*A. albifrons*). Scores indicate values of difference: 0 = identical; 1 = minor differences; 2 = moderate differences; 3 = major differences; and 4 = exceptional differences. Values in brackets indicate sub-scores. ND = no difference. Only the minimum sub-trait value provided the score for the trait.

Table 2. Comparative analysis and magnitude of difference scores of 'Meidum Geese 3′ ('Meidum Geese', Chapel of Itet, Old Kingdom, Egypt) and purported modern candidate taxa Red-breasted geese (*Branta ruficollis*). Scores indicate values of difference: 0 = identical; 1 = minor differences; 2 = moderate differences; 3 = major differences; and 4 = exceptional differences. Values in brackets indicate sub-scores. ND' denotes traits of no difference. Only the minimum sub-trait value provided the score for the trait.

4. Discussion

The 'Meidum Geese' has been credited as having been painted with a "naturalistic attention to detail… unsurpassed in Egyptian art" (Goelet, 1983:41). It is perhaps unsurprising that the results of the current study support the claim that the 'Meidum Geese' depict specific goose species with an acute attention to detail (Nicoll, 1919; Smith, 1937; Raven, 1947; Goelet, 1983; Houlihan, 1986; Strudwick et al., 1990; Arnott, 2009; Wyatt, 2012, 2013; Josephson, 2015), at least for the 'Meidum Geese 1' and 'Meidum Geese 2' depictions.

Interestingly, two related taxa have been nominated for the species depicted as the 'Meidum Geese 1′, greylag geese (*A. anser*) and bean geese (*A. fabalis*). The 'Tobias criteria' excluded neither species as potential subjects, although greylag geese have a greater number of similarities suggesting that this taxon could be a more likely candidate (also see Wyatt, 2013). The assessment of the 'Meidum Geese 2′ as representing the greater white-fronted geese (*A. albifrons*) is also supported by this method. But 'Meidum Geese 3′, while representing geese with red breasts, the 'Tobias criteria' assesses these as not accurately resembling the red-breasted geese (*B. ruficollis*) sensu stricto.

The current study thus conflicts with previous claims that the 'Meidum Geese 3′ as red-breasted geese (*B. ruficollis*) is "certain" (Nicoll, 1919:70), "straightforward" (Wyatt, 2013:2), "well defined" (Houlihan, 1986:61) and has an "unmistakable likeness" (Raven, 1947:i). Instead, this study aligns with the view that this ancient depiction "differs significantly from that of the birds known today" (Weesie, 1988:13), with body regions bearing different colours (e.g., bill, legs, feet, back, and wings), patterning (face, breast), and striking differences between individuals (Goelet, 1983; Houlihan, 1986). But, the 'Tobias criteria' cannot determine whether these series of dissimilarities between 'Meidum Geese 3' and *B. ruficollis* result from an accurate representation of a different contemporaneous species or represent an inaccurately depicted *B. ruficollis* .

Hints that all the 'Medium geese' are realistic depictions is it's context with other meticulously painted, species identifiable animals on the exterior walls of Itet's chapel: northern pintail duck (*Anas acuta*) (Robins, 1997:Fig. 50); leopard (*Panthera pardus*) (Osborn and Osbornová, 1998); side-striped jackal (*Canis adustus*) (Nicolas, 2009) and addax (*Addax nasomaculatus*) (Petrie, 1892), and except for the duck, are taxa that no longer range across Egypt. If the 'Meidum Geese 3′ is an accurate representation, then the enlarged flank-plumes are novel features unknown in any other extant true geese species but present in otherwise very dissimilar Plumed Whistling-ducks (*Dendrocygna eytoni*) (see del Hoyo and Collar, 2014). This raises the possibility that the 'Medium Geese 3′ may illustrate a distinct, yet now extinct goose population as has been suggested previously (in Weesie, 1988:13).

Despite the skilful executions, the ancient artisans were not ornithologists, and it is possible that the graphical representations may not reflect what the ancient Egyptians saw (Strudwick et al., 1990). Instead, such works served a function within the context of their culture (Schäfer et al., 1974), which may have included being expressions of the tomb owner's perceived hopes for the afterlife and/or reflections "that defined that individual in a broader social network" (Wen, 2018:2). The elongate flank plumage may instead be wing-bars, white-tipped margins of the flight feathers occurring in three rows in immature red-breasted geese, as has been interpreted before (Goelet, 1983; Houlihan, 1986). However, the clearly demarcated wing feathers do not have white-margins, and the direction of the white feathers does not conform with the orientation of the feathers of the wing. The artisans of Itet's chapel show that they could accurately represent multicoloured individual feathers, as in the white, green, brown, and grey on the northern pintail duck (The British Museum accession number 33.8.18) (Robins, 1997:Fig. 50). This raises the possibility that the pintail duck, a waterfowl that is abundantly depicted in Egyptian art, known from bones in tomb remains, and is a migrant to modern Egypt (Houlihan, 1986; Wyatt, 2012), was well known and perhaps well studied by the ancient artisans. In contrast, the 'Meidum Geese' are the only depiction and record of red-breasted geese in ancient Egypt, unknown from tomb bone remains, and are very rare vagrants to the country (Goelet, 1983; Houlihan, 1986). Perhaps a rare visit of the striking colour-patterned red-breasted geese were enough to become rendered to the memory of ancient artisans, but were too transitory to be rendered in detail on to the chapel wall of Itet.

Importantly, the use of the 'Tobias criteria' on ancient graphical representations has the potential to remove bias and uncertainties associated with the purported modelled taxa. In this study, the 'Meidum Geese 1 and 2′ accurately reflect *Anser* geese species, but the 'Meidum Geese 3′ does not accurately reflect *B. ruficollis*. Whether the appearance of the 'Meidum Geese 3′ reflects realism, fabrication, or a blend of either is open to discussion.

5. Conclusion

This study is the first to utilise a novel approach to assess the extent

to which an ancient graphical representation plausibly resembles their purported candidate taxa. The 'Tobias criteria' is widely method for modern species limitation but also provides a useful tool to remove bias and uncertainty in the identification of species in ancient artwork. The results support earlier conclusions that greylag geese (and to a lesser degree bean geese) and greater white-fronted geese resemble two of the taxa represented as the 'Meidum Geese' from the Chapel of Itet. However, our results also show the resemblance of 'Meidum Geese 3′ red-breasted geese is implausible. Given the skilful and naturalistic representation of these and other animals painting at the Chapel of Itet, it is possible that the 'Meidum Geese 3′ represents an extinct taxon that has no modern counterpart, or a partially accurate extant but locally extinct species, or a fabricated bird that includes elements of goose morphologies.

CRediT authorship contribution statement

A. Romilio: Conceptualization, Methodology, Visualization, Investigation, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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